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Prof. J. Lederberg
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Dear Dr. Lederberg:

Thank you for sending me the clippings. I had greeted your letter to the New York Times with considerable relief: your voice is authoritative enough to close this needless debate.

Data on secondary meteorites from the moon come from a variety of sources.

1. Total influx of cosmic matter. The enclosed paper by Barker and myself probably gives the most reasonable estimate: around $10^5$ tons/yr for the last $10^5$ years. Much of this is in the form of large, crater-forming objects, which are not germane to our discussion. But the material in the range $10^{-4}$ to $10^2$ cm probably comprises $10^3$-$10^4$ tons/yr.

2. Fraction of lunar meteorites. Here we have two estimates.
a. Jacchia and Whipple (enclosure) suggest that ~1% of the photographic meteors ($\approx 10^{-4}$ - 1 g) might be of lunar origin, judging from their small aphelia and low geocentric velocity. Their sample of 413 contained only one possible lunar case, but since their selection was biased in favor of high-velocity meteors with long, well-defined trails, the data from two other surveys are more meaningful. Hawkins and Southworth found 6 low-velocity meteors among 359, while McCrosky found 1 low-velocity object among 100 fireballs photographed by the Prairie Network. McCrosky's objects extend well into the meteoritic range, $10^2$ - $10^6$ g.
b. Opik (enclosure) has tried to estimate the fraction of lunar meteorites from his cratering theory. He comes up with a frequency of $\leq$1% among stones $\geq$100 cm in diameter.
c. Some 7 years ago, I dealt with this question in a different context. (Science, 138, 431, 1962) I tried to prove that the majority of meteorites could not be of lunar origin, as Harold Urey had proposed. My conclusions although based in part on guesses, are consistent with more recent evidence.

3. Fraction of material not melted or heat-sterilized. This is very hard to estimate. If the impact energy is apportioned equally between kinetic and internal energy (as one generally assumes on experimental and theoretical grounds) then material accelerated to lunar escape velocity should be heated to close to its melting point. But some fraction of the material probably gets through without severe heating: material spalled off the surface of a crater (Öpik), ejecta from the impact of a comet (Arnold), material accelerated by rapidly expanding gases (O'Keefe). Some of these mechanisms have not been worked out quantitatively, but I think it is not unreasonable to suppose that a small amount, say 0.1% - 1% of lunar ejecta, get through unscathed.

The enclosed paper by Arnold (pp. 1552-3, and 1555) contain a few more remarks on this point. Donald Gault at the Ames Research Center is a leading expert on hypervelocity impact, and may be able to provide you with some further educated guesses.

Kind regards.

Sincerely yours,

Edward Anders

EA/sc
Encl.